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Effect of urbanization on the diurnal rainfall pattern in Houston

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Abstract:

Data from 19 raingauges located within and nearby Houston were analysed to quantify the impact of urbanization of the Houston metropolitan area on the local diurnal rainfall pattern. The average annual and warm-season diurnal rainfall patterns were determined for one time period when Houston was relatively small and likely would not have had a significant effect on meteorological processes (1940–58) and for a second, more recent, time period after Houston had become a major metropolitan area (1984–99). The diurnal rainfall patterns within the hypothesized urban-affected region and an upwind control region were compared for the pre- and post-urban time periods. Results indicated that the diurnal rainfall distribution in the urban area is much different than that found for the upwind and downwind adjacent regions for the 1984 to 1999 time period. For an average warm season from 1984 to 1999, the urban area and downwind urban-impacted region registered 59% and 30% respectively greater rainfall amounts from noon to midnight than an upwind control region. Moreover, the urban area had approximately 80% more recorded rainfall occurrences between noon and midnight during the warm season than surrounding areas. Comparison of the pre- and post-urban rainfall patterns indicated that the diurnal rainfall distribution has changed in southeast Texas. The changes are most significant in the urban area, especially for the afternoon time increments during the warm season. The average warm-season rainfall amount registered in the urban area increased by 25% from the pre- to the post-urban time period, while the amount in the upwind control region decreased by 8%. The majority of the increase was observed for the noon to 4 p.m. and 4 p.m. to 8 p.m. time increments. Copyright © 2005 John Wiley & Sons, Ltd.

KEY WORDS inadvertent weather modification; urbanization; diurnal rainfall distribution

INTRODUCTION

Urbanization alters the appearance of the natural landscape and perturbs Earth system processes. The hydrological cycle, in particular, is changed during construction as vegetation is removed, the soil layer is modified, and built structures and drainage infrastructure are introduced. In general, development activities within a watershed will reduce infiltration and groundwater recharge, increase surface runoff volumes and rates, reduce soil moisture, and modify the spatial distribution and magnitude of surface storage and fluxes of water and energy. The perturbed post-development hydrological processes can contribute to increased frequencies and magnitudes of nuisance and severe floods, accelerated geomorphologic changes to downstream waterways, and aquatic habitat impacts. Urban drainage controls are designed and constructed to mitigate hydrological impacts of development. Design procedures are based on providing adequate conveyance, infiltration, and/or storage capacity to control the modified surface runoff produced by rainstorms. The change in watershed characteristics between pre- and post-development is included in the design by performing the runoff calculations for post-development conditions. However, the change in the rainfall characteristics possibly caused by urbanization is not accounted for in the traditional design process, whereby the design storm is

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